

FOURTH EDITION

INDUSTRIAL SAFETY AND HEALTH MANAGEMENT

C.RAY ASFAHL

UNIVERSITY OF ARKANSAS



Prentice Hall, Upper Saddle River, New Jersey 07458

0028018

Asfahl, C. Ray

Industrial Safety and Health Management/ C. Ray Asfahl — 4th ed.
p. cm.—(Prentice Hall International Series in industrial
and systems engineering)

Includes bibliographical references and index.

ISBN 0-13-895350-3

1. Industrial Safety 2. Industrial hygiene I. Title. II. Series

55.A83. 1999

:8--dc21

97-27372

CIP

Acquisitions editor: Bill Stenquist
Editor-in-chief: Marcia Horton
Project manager: AnnMarie Longobardo
Copy editor: Peter Zurita
Director of production and manufacturing: David W. Riccardi
Art director: Jayne Conte
Managing editor: Eileen Clark
Page Composition: Ann Marie Longobardo
Cover designer: Karen Salzbach
Manufacturing buyer: Pat Brown
Editorial assistant: Meg Weist



© 1995, 1999 by Prentice-Hall, Inc.

Simon & Schuster/A Viacom Company

Upper Saddle River, New Jersey 07458

All rights reserved. No part of this book may be reproduced, in any form or by any means, without permission in writing from the publisher.

The author and publisher of this book have used their best efforts in preparing this book. These efforts include the development, research, and testing of the theories and programs to determine their effectiveness. The author and publisher make no warranty of any kind, expressed or implied, with regard to these programs or the documentation contained in this book. The author and publisher shall not be liable in any event for incidental or consequential damages in connection with, or arising out of, the furnishing, performance, or use of these programs.

Printed in the United States of America

0 9 8 7 6 5 4 3 2

ISBN 0-13-895350-3

Prentice-Hall International (UK) Limited, London
Prentice-Hall of Australia Pty. Limited, Sydney
Prentice-Hall Canada, Inc., Toronto
Prentice-Hall Hispanoamericana, S.A., Mexico
Prentice-Hall of India Private Limited, New Delhi
Prentice-Hall of Japan, Inc., Tokyo
Simon & Schuster Asia Pte. Ltd., Singapore
Editora Prentice-Hall do Brasil, Ltda., Rio de Janeiro

**PRENTICE HALL INTERNATIONAL SERIES
IN INDUSTRIAL AND SYSTEMS ENGINEERING**

W. J. Fabrycky and J. H. Mize, Editors

- Amos and Sarchet *Management for Engineers*
Amrine, Ritchey, Moodie, and Kmec *Manufacturing Organization and Management, 6/E*
Asfahl *Industrial Safety and Health Management, 4/E*
Babcock *Managing Engineering and Technology, 2E*
Badiru *Expert Systems Applications in Engineering and Manufacturing*
Banks and Carson and Nelson *Discrete-Event System Simulation, 2E*
Blanchard *Logistics Engineering and Management, 5/E*
Blanchard and Fabrycky *Systems Engineering and Analysis, 3/E*
Brown *Technimanagement: The Human Side of the Technical Organization*
Bussey and Eschenbach *The Economic Analysis of Industrial Projects, 2/E*
Buzacott and Shanthikumar *Stochastic Models of Manufacturing Systems*
Canada and Sullivan *Economic and Multi-Attribute Evaluation of Advanced Manufacturing Systems*
Canada, Sullivan and White *Capitol Investment Analysis for Engineering and Management, 2E*
Chang and Wysk *An Introduction to Automated Process Planning Systems*
Chang, Wysk, and Wang *Computer Aided Manufacturing, 2E*
Eager *The information Payoff: The Manager's Concise Guide to Making PC Communications Work*
Eberts *User Interface Design*
Eberts and Eberts *Myths of Japanese Quality*
Elsayed and Boucher *Analysis and Control of Production Systems, 2/E*
Fabrycky and Blanchard *Life-Cycle Cost and Economic Analysis*
Fabrycky and Thuesen and Verma *Economic Decision Analysis, 3/E*
Fishwick *Simulation Model Design and Execution: Building Digital Worlds*
Francis, McGinnis and White *Facility Layout and Location: An Analytical Approach, 2/E*
Gibson *Modern Management of the High-Technology Enterprise*
Gordon *Systematic Training Program Design*
Graedel and Allenby *Industrial Ecology*
Hall *Queuing Methods: For Services and Manufacturing*
Hammer *Occupational Safety Management and Engineering, 4/E*
Hansen *Automating Business Process Reengineering*
Hazelrigg *Systems Engineering*
Hutchinson *An Integrated Approach to Logistics Management*
Ignizio *Linear Programming in Single- and Multiple-Objective Systems*
Ignizio and Cavalier *Linear Programming*
Kroemer, Kroemer, Kroemer-Elbert *Ergonomics: How to Design for Ease and Efficiency*
Kusiak *Intelligent Manufacturing Systems*
Lamb *Availability Engineering and Management for Manufacturing Plant Performance*
Landers, Brown, Fant, Malstrom, Schmitt *Electronics Manufacturing Processes*
Leemis *Reliability: Probabilistic Models and Statistical Methods*
Michaels *Technical Risk Management*
Moody Chapman, Van Voorhees and Bahill *Metrics and Case Studies for Evaluating Engineering Designs*
Mundel and Danner *Motion and Time Study: Improving Productivity, 7/E*
Ostwald *Engineering Cost Estimating, 3/E*
Pinedo *Scheduling: Theory, Algorithms, and Systems*
Prasad *Concurrent Engineering Fundamentals, Vol. I: Integrated Product and Process Organization*
Prasad *Concurrent Engineering Fundamentals, Vol. II: Integrated Product Development*
Pulat *Fundamentals of Industrial Ergonomics*
Shtub, Bard, Globerson *Project Management: Engineering Technology and Implementation*
Taha *Simulation Modeling and SIMNET*
Thuesen and Fabrycky *Engineering Economy, 8/E*
Turner, Mize, Case, and Nazemetz *Introduction to Industrial and Systems Engineering, 3/E*
Turtle *Implementing Concurrent Project Management*
Von Braun *The Innovation War*
Walesh *Engineering Your Future*
Wolff *Stochastic Modeling and the Theory of Queues*

INDUSTRIAL SAFETY AND HEALTH MANAGEMENT

Introduction

PREFACE

The Safety and Health Manual

To my partner Kela

Recordkeeping

Accident Cause Analysis

Bloodborne Pathogens

Electrical Safety

Fire Safety

First Aid and CPR

Preface

This book binds together the traditional examination of time-tested concepts and techniques of safety and health management with a modern perspective on compliance with mandatory standards for workplace safety and health. It is intended to add reason, explanation, and illustration of the hazard mechanisms that form the underlying basis for the volumes of detailed standards for workplace safety and health. Industrial managers know the value of finding the relevant and essential material to understand and develop a strategy for bringing their organizations into compliance with standards, reducing Workers' Compensation claims due to injuries and illnesses, improving productivity, and enhancing the overall well-being of their employees and their workstations.

As the twentieth century draws to a close, dramatic changes have been seen to impact the field of industrial safety and health management. The most notable of these is the instant availability of detailed information on almost any subject pertaining to health and safety. Since the inception of OSHA three decades ago, one of the principal problems facing the Safety and Health Manager has been how to find the relevant and essential information to do the job. OSHA published large volumes of detailed, mandatory standards. What was needed, though, was a strategy or guidance for coming into compliance with the volumes standards. Also needed was understanding of the hazards so that the rationale behind the standards could justify effective actions to come into compliance. Compliance with standards often requires analysis, planning, capital investment, and follow-through training. Such a process is better justified by a comprehensive understanding of the benefits of compliance beyond the mere avoidance of OSHA fines. One of these benefits is the reduction in Workers' Compensation costs, costs that have recently captured more attention from management as a significant component of direct labor costs.

The fourth edition of this book recognizes and takes advantage of the new and readily available sources of information now accessible to the Safety and Health Manager. The OSHA CD-ROM computer database, now accessible to the public at low cost, makes available OSHA standards interpretations, OSHA enforcement prior-

ities, variances, inspection statistics, and advance notices of new standards in the making. Even more data are available on the Internet, with convenient access by means of effective keyword search engines. These convenient sources of data have been used not only to enhance the content of this book, but also to challenge students by providing research exercises for further study of the topics using the OSHA CD-ROM, the Internet, or conventional libraries to gather more data. The strategy of the fourth edition, then, is not to merely teach information on the various topics of industrial safety and health, but to empower students to readily find their own answers to questions relevant to their mission.

Every chapter has been changed in the fourth edition. The growing subject of occupational health and environmental control has resulted in a decision to split that topic into two chapters, Chapters 8 and 9. The end-of-chapter exercises and study questions have been expanded at least 20% with new problems and exercises in every chapter; in some chapters, the exercises have been increased by 50%. New in the fourth edition are research exercises, which call upon the student to answer questions for which the data are not directly available in this book. These questions can be answered by those students who have access to the Internet or to the OSHA CD-ROM or comprehensive conventional libraries. All questions that require these additional sources of information are identified as "research exercises," so that students who do not have access to these additional sources of information can still be assigned other exercises supplied at the end of the chapters.

Instructors who teach from this text are advised to contact their Prentice Hall representatives to take advantage of the free comprehensive Instructor's Manual and computer disk available to instructors only. The teaching aids include answers to the end-of-chapter exercises, audiovisual suggestions for every chapter, additional supporting information for every chapter, and a quiz bank of more than 1000 questions for convenient use in composing comprehensive examinations covering the subject matter. Also available are answer keys for every quiz question and page references to the text to help in settling any debates that may be raised by students who attempt to negotiate their sources after examination. Most of the quiz bank and almost all of the end-of-chapter exercises have been classroom tested. Difficulties with any of the material can be resolved by accessing the author's homepage on the Internet. Also available via the Internet are lecture outlines for each chapter, with additional notes supplied for enhancing the classroom lectures.

The many additions to the fourth edition would not have been possible without the advice and assistance of students and respected colleagues from both academia and industry. Mr. Jun-Pin Wong was especially helpful in the generation of cost data, especially the hidden costs of accidents. Mr. Bud Daven and Dr. Sharon Meador were helpful with the latest developments in Workers' Compensation laws. Others who provided valuable assistance are Jeff Hinkle, Jeff Hardcastle, Christopher Mazur, Luke Chong, Nick McConnell, Paula Roberts, Clyde Ragland, and Karen Standley.

Contents

PREFACE

xvii

1 The Safety and Health Manager

1

- A Reasonable Objective 2
- Safety versus Health 4
- Role in the Corporate Structure 5
- Resources at Hand 6
- Summary 9
- Exercises and Study Questions 10

2 Development of the Safety and Health Function

13

- Workers' Compensation 14
- Recordkeeping 17
- Accident Cause Analysis 28
- Organization of Committees 31
- Safety and Health Economics 32
- Training 35
- Job Placement Testing 37
- The Smoke-Free Workplace 38
- Bloodborne Pathogens 39
- Workplace Violence 40
- Summary 41
- Exercises and Study Questions 42

3	Concepts of Hazard Avoidance	47
	The Enforcement Approach	47
	The Psychological Approach	50
	The Engineering Approach	51
	The Analytical Approach	59
	Hazards Classification Scale	68
	Summary	75
	Exercises and Study Questions	75
4	Impact of Federal Regulation	81
	Standards	81
	NIOSH	86
	Enforcement	86
	Public Uproar	91
	Role of the States	93
	Future Trends	94
	Summary	98
	Exercises and Study Questions	99
5	Information Systems	103
	Hazard Communication	104
	Environmental Protection Agency	109
	Computer Information Systems	113
	Summary	116
	Exercises and Study Questions	116
6	Process Safety	119
	Process Information	120
	Process Analysis	124
	Operating Procedures	125

Training	125
Contractor Personnel	126
Summary	127
Exercises and Study Questions	127

7 Buildings and Facilities 129

Walking and Working Surfaces	130
Exits	140
Illumination	141
Miscellaneous Facilities	142
Sanitation	144
Summary	145
Exercises and Study Questions	145

8 Health and Environmental Control 147

Baseline Examinations	147
Toxic Substances	148
Measures of Exposure	157
Standards Completion Project	161
Detecting Contaminants	161
Summary	167
Exercises and Study Questions	169

9 Environmental Control and Noise 175

Ventilation	175
Industrial Noise	182
Radiation	197
Computer Terminals	198
Summary	198
Exercises and Study Questions	199

10	Flammable and Explosive Materials	203
	Flammable Liquids	203
	Sources of Ignition	208
	Standards Compliance	209
	Combustible Liquids	210
	Spray Finishing	212
	Dip Tanks	215
	Explosives	216
	Liquefied Petroleum Gas	216
	Conclusion	218
	Exercises and Study Questions	218
11	Personal Protection and First Aid	221
	Hearing Protection	222
	Eye and Face Protection	224
	Respiratory Protection	225
	Confined Space Entry	235
	Head Protection	238
	Miscellaneous Personal Protective Equipment	239
	First Aid	241
	Conclusion	242
	Exercises and Study Questions	242
12	Fire Protection	245
	Industrial Fires	246
	Fire Prevention	246
	Emergency Evacuation	247
	Fire Brigades	248
	Fire Extinguishers	249
	Standpipe and Hose Systems	251

Automatic Sprinkler Systems	252
Fixed Extinguishing Systems	252
Summary	254
Exercises and Study Questions	254

13 Materials Handling and Storage 257

Materials Storage	258
Industrial Trucks	258
Cranes	264
Slings	277
Conveyors	281
Lifting	282
Summary	284
Exercises and Study Questions	284

14 Machine Guarding 287

General Machine Guarding	287
Safeguarding the Point of Operation	296
Power Presses	303
Grinding Machines	321
Saws	324
Belts and Pulleys	329
Summary	332
Exercises and Study Questions	333

15 Welding 337

Process Terminology	337
Gas Welding Hazards	341
Arc Welding Hazards	348
Resistance Welding Hazards	349

Fires and Explosions 350
Eye Protection 352
Protective Clothing 352
Gases and Fumes 353
Summary 356
Exercises and Study Questions 356

16 Electrical Hazards 359

Electrocution Hazards 359
Fire Hazards 371
Test Equipment 377
Frequent Violations 378
Summary 380
Exercises and Study Questions 380

17 Construction 385

General Facilities 386
Personal Protective Equipment 386
Fire Protection 389
Tools 389
Electrical 392
Ladders and Scaffolds 393
Floors and Stairways 396
Cranes and Hoists 396
Heavy Vehicles and Equipment 400
Trenching and Excavations 403
Concrete Work 407

Steel Erection	408
Demolition	409
Explosive Blasting	410
Electric Utilities	411
Summary	412
Exercises and Study Questions	413

Bibliography	417
---------------------	------------

Appendices

A	OSHA Permissible Exposure Limits	425
B	Medical Treatment	443
C	First-Aid Treatment	444
D	Classification of Medical Treatment	445
E	Highly Hazardous Chemicals, Toxics, and Reactives	447
F	Standard Industrial Classification (SIC) Code	450
G	States Having Federally Approved State Plans for Occupational Safety and Health Standards and Enforcement	451
	Glossary	453
	Index	462

CHAPTER 1

The Safety and Health Manager

Everyone wants a safe and healthful workplace, but what each person is willing to do to achieve this worthwhile objective can vary a great deal. As a result, the management of each firm must decide at what level, along a broad spectrum, the safety and health effort will be aimed. Some managers deny this responsibility and attempt to leave the decision to employees. This strategy seems to square with hallowed principles of personal freedom and individual responsibility. But such a denial of responsibility by management results in a decision by default, and usually the result is a relatively low level of safety and health in the workplace.

Is the foregoing an indictment on the judgment of the individual worker? Not really, because without a commitment on the part of management, the worker usually is unable singlehandedly to build safety into his or her job station. The behavior of the worker is the most important determinant for his or her safety, but behavior alone cannot make a dangerous job safe. Furthermore, even if a given worker has a strong inclination to be careful and to guard his or her health, there are plenty of production motivations and other quite natural incentives to undermine safe attitudes when management has not made a commitment to safety and health.

One person, usually designated as Safety Director or Industrial Hygienist, sets the tone of the safety and health program within a firm. In fact, right at the start, it says something about the commitment of management when a firm decides to designate a person by title to the responsibility of safety and health. But naming someone Safety Director or Manager of Safety and Health is just a beginning step. Many such persons have little authority and have been largely ignored by management and worker alike, especially in the past. It was not unusual for a Safety Director's work to be typified by public relations activities, such as posting motivational signs and compiling statistics. These are still important functions, but much more responsibility for this function is now recognized.

Something happened in the 1970s to change dramatically the role of the typical Safety Director in industrial firms throughout the country. The passage of the Occupational Safety and Health Act of 1970 created the Occupational Safety and Health Administration (OSHA), a federal agency whose regulations would have a large impact on the role of the typical Safety Director. Chapter 4 discusses this impact in detail, but the balance of this chapter discusses the enlarged role of the person charged with industrial safety and health.

There is little doubt that OSHA enhanced the authority of the Safety Manager in the typical industrial plant in the United States. Prior to OSHA, few Safety Managers

dared to interfere with production schedules to alleviate a safety or health problem. But prominent OSHA cases in the news media have brought to the attention of top management personnel the dire consequences that can ensue when serious safety or health problems are not adequately addressed.

The field of occupational health has probably benefited even more from OSHA than has the field of occupational safety. Prior to OSHA, occupational health seemed to be a matter too remote to really concern anyone, except perhaps the plant nurse. And the plant nurse had little authority to influence policy or even to take action to prevent hazards. Prior to OSHA, the plant nurse was chiefly concerned with first aid, after the fact, and physical examinations, not with hazard abatement and prevention.

In describing the functions of today's executive charged with the safety and health responsibility, this text will use the designation *Safety and Health Manager*, recognizing the dual nature of the job. Also, the term *manager* envisions the enlarged scope of responsibility, which includes analysis of hazards, compliance with standards, and capital investment planning, in addition to the conventional functions described earlier. The purpose of this book is to provide tools and guidelines to Safety and Health Managers to help them execute their enlarged duties.

Dealing with applicable standards is one of the greatest challenges facing today's Safety and Health Manager, and to meet this challenge is a primary purpose of this book. Since only 10% of the standards generate 90% of the activity, Safety and Health Managers need guides to the important parts of the standards. Frequently cited standards should receive prime attention because they indicate areas in which industries are having difficulty complying or areas in which enforcement agencies are giving a great deal of attention. In either event, Safety and Health Managers have a need to know these frequently cited standards so that they can bring their facilities within compliance. Besides the frequency of citation, Safety and Health Managers need to know the "why" behind the standards. Until the Safety and Health Manager learns what hazards a particular standard is intended to prevent, he or she will have a difficult time persuading either management or employees that a given situation needs correction.

A REASONABLE OBJECTIVE

Top management sometimes turns a deaf ear to the pleas of the Safety and Health Manager for plant improvements. But the Safety and Health Manager is sometimes a crusader with a one-track mind. Any Safety and Health Manager who feels that elimination of workplace hazards is an indisputable goal is naive. In the real world, we must choose among:

1. Hazards that are physically infeasible to correct
2. Hazards that are physically feasible, but are economically infeasible to correct
3. Hazards that are economically and physically feasible to correct

Until the Safety and Health Manager comes to grips with this reality, he or she cannot expect to enjoy the approval of top management. Some Safety and Health